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RESPONSE OF NORTHERN GOSHAWKS TO TAPED CONSPECIFIC AND GREAT HORNED OWL CALLS

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Abstract.—We compared responses of Northern Goshawks (*Accipiter gentilis*) to conspecific "kakking" and Great Horned Owl (*Bubo virginianus*) "hooting" calls during the 1989 breeding season in Pennsylvania. Calls were played 150 and 300 m from active goshawk nests during nestling (7 nests, N = 27 trials) and fledgling (7 nests, N = 28 trials) periods. Five nests were tested during both nestling and fledgling periods. Response rate of goshawks to calls played at 150 m was highest for conspecific calls during the nestling period (0.71) and lowest for owl calls during the fledgling period (0.14). Goshawk response rate to conspecific calls at 300 m during nestling and fledgling periods was 0.29 each, and no response was detected to owl calls at 300 m during either period. Response rates of goshawks differed significantly both for type of call and broadcast distance, due largely to the lack of response by goshawks to owl calls at 300 m. During the nestling period, goshawks responded in significantly less time to conspecific (median = 13 sec) than to owl calls (95 sec) at 150 m. There were no differences in response rates relative to time of day or period of breeding season, but adult goshawks were observed near nests more frequently during the nestling versus the fledgling period. Based on our findings, we recommend that conspecific "kakking" calls be used for censuses of Northern Goshawks during nestling and early fledgling periods, and that calls be played along transects that are spaced no more than 300 m apart.

Respuestas de Gavilán Azor (*Accipiter gentilis*) a reproducciones de grabaciones de las llamadas de su misma especie, ó, a las de las llamadas del buho de la especie *Bubo virginianus*

Extracto.—Hemos comparado las respuestas de Gavilán Azor (*Accipiter gentilis*) a las llamadas ("kak-kak") grabadas de su misma especie, con las respuestas a las llamadas ("jut-jut") grabadas del buho de la especie *Bubo virginianus,* durante la época de reproducción en 1989, en Pennsylvania. Las grabaciones fueron reproducidas a distancias de 150 y 300 metros de nidos activos de los gavilanes tanto durante los períodos de cría de los polluelos (7 nidos, N = 27 pruebas), como durante los períodos de los primeros vuelos (7 nidos, N = 28 pruebas). Las pruebas se realizaron con cinco nidos durante esos dos períodos. La proporción de las respuestas de los gavilanes, a las llamadas reproducidas a 150 metros, fue más alta con llamadas de su misma especie durante el período de cría de los polluelos en el nido (0.71), y más baja con llamadas de buhos (*Bubo virginianus*) durante el período de los primeros vuelos (0.14). La proporción de las respuestas a reproducciones de llamadas de su especie, a una distancia de 300 metros, durante el período de crianza y el de los primeros vuelos, fue de 0.29 cada una. No se detectó respuesta alguna a reproducciones de las llamadas ("jut-jut") de buho, para ninguno de estos períodos y a la misma distancia. Las proporciones de respuesta de los gavilanes fueron, significativamente diferentes, en el caso de las pruebas con el tipo de llamada (de la misma especie o de especie diferente) y en el de las pruebas de distancia de la llamada, debido mayormente a la falta de respuestas a las llamadas de buhos, emitidas a 300 metros del nido. Durante el período de cría en el nido, a 150 metros de distancia, los gavilanes respondieron en un tiempo significativamente menor, a las emisiones de las llamadas de su misma especie (media = 13 segundos), que a las emisiones de las llamadas de buhos (95 segundos). No se notaron diferencias en la proporción de las respuestas, en relación con la hora del día o el tiempo del período de reproducción; pero sí se observó que los gavilanes adultos estaban cerca a sus nidos más frecuentemente durante el período de crianza, que durante el período de los primeros vuelos. Basados en nuestros resultados, recomendamos que para censar Gavilanes Azor (*Accipiter gentilis*) sean usadas grabaciones de las llamadas ("kak-kak") emitidas por la misma especie, tanto durante el período de crianza de los polluelos como a principios del período de los primeros vuelos. También recomendamos que las llamadas sean emitidas en secciones espaciadas a no más de 300 metros entre ellas.

[Traducción de Eudoxio Paredes-Ruiz]

Taped calls of avian vocalizations have been used to detect a variety of raptor species (Fuller and Mosher 1981, Johnson et al. 1981). Red-shouldered (*Buteo lineatus*), Broad-winged (*B. platypterus*), Red-tailed (*B. jamaicensis*), Sharp-shinned (*Accipiter striatus*), and Cooper's Hawks (*A. cooperii*) respond to broadcasts of conspecific vocalizations (Balding and Dibble 1984, Fuller and Mosher 1981, 1987,

DAY	Early a.m.	Late a.m.	Early p.m.	Late p.m.
	TIME OF DAY			
1	NEST A GOS-150	NEST B OWL-150	NEST A OWL-300	NEST B GOS-300
2	NEST B OWL-300	NEST A GOS-300	NEST B GOS-150	NEST A OWL-150
3	NEST C OWL-150	NEST D GOS-150	NEST C GOS-300	NEST D OWL-300
4	NEST D GOS-300	NEST C OWL-300	NEST D OWL-150	NEST C GOS-150

Figure 1. Modified Latin square used to schedule trials for testing response of Northern Goshawks to taped calls played near active nests. Conspecific (GOS) and Great Horned Owl (OWL) calls were played at 150 and 300 m from nests.

Rosenfield et al. 1985, 1988). Fuller and Mosher (1987) reported that Red-shouldered and Cooper's Hawks responded as readily to taped calls of the Great Horned Owl (*Bubo virginianus*) as to conspecific calls. They also noted the value of using the call of a single species, such as that of the Great Horned Owl, to increase the efficiency of surveys intended for multiple raptor species.

Despite the fact that Northern Goshawks (*Accipiter gentilis*) also are known to respond to taped calls (Hennessy 1978, Fuller and Mosher 1981), little information is available regarding the application of this technique for goshawk surveys or censuses. Our objectives were to (1) compare responses of goshawks to taped conspecific and Great Horned Owl calls played at two distances from active nests, and (2) evaluate the effects of time of day and period of breeding season on response rates of goshawks to these calls. Results of our study will be useful in developing a standard census technique for nesting goshawks.

MATERIALS AND METHODS

The study was conducted at nine active nests of Northern Goshawks located in six counties in central and northern Pennsylvania, USA, in 1989. Five of the nine nests were used for trials during both nestling and fledgling periods.

A modified Latin square design was used to schedule trials at nests (Fig. 1). This design maximized independence of the four experimental factors (Sokal and Rohlf 1981:393) and helped control for possible variation in response rate due to sequential visitation of nests to conduct trials. Experimental factors considered for each trial were type of call (defensive "kakking" call of a Northern Goshawk or territorial "hooting" call of a Great Horned Owl), distance from nest (150 or 300 m), time of day (early morning 0800–1000 H, late morning 1001–1200 H, early afternoon 1201–1500 H, or late afternoon 1501–1800 H), and period of breeding season (nestling or fledgling period).

A balanced design required grouping nests in sets of four (i.e., two pairs), with trials at each pair conducted twice daily for 2 consecutive days. Our goal was to test taped calls at two sets of four nests (i.e., eight nests) during both nestling and fledgling periods. However, the widely dispersed nature of goshawk nests combined with nest failure of several nests limited the number of nests for use in our study and resulted in trials being conducted at only seven nests during each period. Twenty-seven trials were conducted during the nestling period (30 May–16 June, mean estimated age of young = 28 d, range = 21–37 d), and 28 trials were conducted during the fledgling period (14 June–4 July; mean estimated age of young = 53 d, range = 46–64 d). Only three trials were conducted at the Warren Co. #4 nest during the nestling period. An owl call was not played at 300 m from this nest because an adult goshawk detected us and vocally responded as we approached the broadcast station; we were unable to complete this trial at a later date.

Logistics of travelling between nests to conduct trials required the grouping of nests in pairs based on geographic proximity. Thus, complete randomization of nests within the experimental design was not feasible. However, pairs of nests were assigned randomly within the design.

Recordings of Northern Goshawk and Great Horned Owl calls were obtained from the Cornell Library of Natural Sounds (Laboratory of Ornithology, Cornell University, Ithaca, New York) and were broadcast with a portable Realistic CRT-7 cassette tape player and Half-Mile Hailer (Perma Power Electronics, Inc., 5615 West Howard Ave., Chicago, Illinois). Audio output was adjusted to 100–110 db at 1 m in front of the speaker (after Fuller and Mosher 1987) using a Realistic sound level meter set on C-weighting and slow-response.

Broadcast stations were established 150 and 300 m from active goshawk nests at least one week prior to experimental trials, and each was marked with vinyl flagging. Stations were situated so that the slope of a straight line between the station and the nest did not exceed 10% and the area between station and nest was continuous forest and unobstructed by terrain. None of the nests used for experimentation was located initially with taped calls, but all were reported to us by various sources (bird-watchers, foresters, etc.).

We wore camouflage clothing during each trial to avoid detection by goshawks. After arriving at a station, we waited quietly for 5 min before beginning the trial. Each trial consisted of playing six bouts of goshawk calls (25–30 "kaks" over 7 sec) or owl calls (seven "hoots" over 2 sec) spaced evenly over a 5-min period (Fuller and Mosher 1987) with the speaker oriented toward the nest. We recorded type of response (approach but no vocalization, vocalization but no detectable approach, or approach and vocalization), time (sec) from initiation of playback to detection of response, and sex and age of responding bird(s) for all detectable goshawk responses. If no responses were detected, we waited quietly for an additional 5 min and approached the nest to determine the presence of adult or young goshawks.

Table 1. Response rates of Northern Goshawks to taped calls (proportion of trials with detectable responses) at nine active nests in Pennsylvania, 1989. Trials during nestling and fledgling periods consisted of four call-distance combinations (conspecific and Great Horned Owl calls at 150 and 300 m) played at each nest at four times of day. Results of trials when adults were known or presumed to be near nests are shown in parentheses.

	Period of Breeding Season			
	Nestling		Fledgling	
Nest	N = 27	(N = 20)	N = 28	(N = 14)
Elk Co. #2	0.50	(0.67)	0.25	(0.25)
Elk Co. #6[a]	0.50	(0.50)	—	(—)
Forest Co. #3[b]	—	(—)	0.00	(0.00)[c]
McKean Co. #1	0.00	(0.00)[c]	0.25	(1.00)
Potter Co. #3	0.50	(1.00)	0.00	(—)[d]
Snyder Co. #1[b]	—	(—)	0.25	(1.00)
Warren Co. #4[a]	0.67[e]	(1.00)	—	(—)
Warren Co. #6	0.50	(0.50)	0.75	(0.75)
Warren Co. #7	0.25	(0.50)	0.25	(1.00)

[a] No trials conducted during fledgling period due to nest failure.
[b] Nest discovered during fledgling period.
[c] Adults presumed to be present near nest during 3 trials.
[d] Adult(s) not observed near nest during or following any trials.
[e] Only 3 trials; no Great Horned Owl call played at 300 m.

Response rate of goshawks to calls was defined as the proportion of trials for which goshawk responses were detected. Differences in response between or among levels of experimental factors were tested using Fisher's exact test or a *G*-test of independence, depending on size of cells (Sokal and Rohlf 1981:735). Difference in median time for detectable goshawk response to owl versus conspecific calls was tested with a two-tailed Wilcoxon two-sample test (Sokal and Rohlf 1981:432) and reported as a Chi-square approximation. Statistical significance was $P < 0.05$ for all tests.

We presumed that adult goshawks were not present near nests during some trials. Evidence for this was the apparent absence of adults at some nest sites when we approached nests after trials with no detectable responses. Because we were uncertain of the location of adults during trials that yielded no detectable responses (i.e., adults might have left before, or arrived shortly after, the end of a trial), response rates were evaluated both for all trials conducted (hereafter referred to as "total trials") and for only those trials when adults were known or presumed to be near nests ("trials with adults present").

Results

Goshawk responses to taped calls were detected for 18 of 55 (33%) total trials (Table 1). We attempted to determine the presence of adult goshawks near nests following 36 of the 37 trials for which no responses were detected. Adults were observed near nests following 9 of 15 (60%) and 7 of 21 (33%) of these trials during nestling and fledgling periods, respectively. Thus, responses were detected for 18 of the 34 (53%) trials with adults present. Response rates by goshawks at any given nest per period of the breeding season (4 call-distance combinations combined) ranged from 0.0 to 0.75 for total trials and 0.0 to 1.0 for trials with adults present (Table 1).

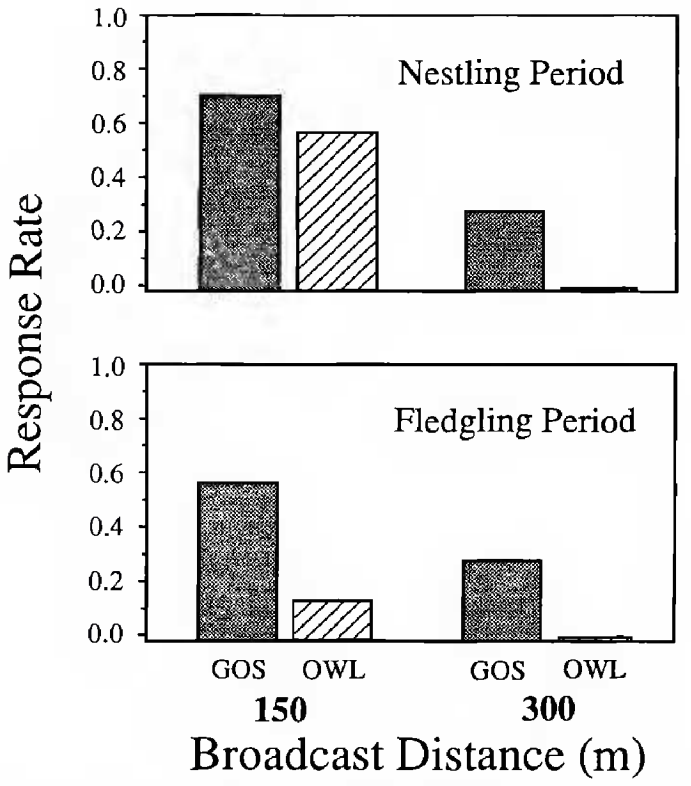

Figure 2. Response rates of Northern Goshawks to conspecific (GOS) and Great Horned Owl (OWL) calls played at 150 and 300 m from active goshawk nests during nestling and fledgling periods (N = 55 trials).

Behavior of goshawks responding to taped calls ranged from silent approach to approach with vocalization, and 15 of the 18 (83%) detectable responses included vocalizations. Vocal responses to conspecific and owl calls, respectively, included five and one without approach and six and three with approach. Seventeen of the 18 (94%) detectable responses were by single adult goshawks, presumed in most cases to be females of the breeding pairs. One response was a non-vocal approach by a fledgling 20 sec after termination of a conspecific broadcast at 150 m.

Effects of Experimental Factors. Response rates for total trials generally were lower during the fledgling period, particularly for the owl call (Fig. 2). Also, adult goshawks were detected near nests more frequently during the nestling period than during the fledgling period ($G = 4.3$, $P = 0.04$). Nonetheless, differences in response rates between nestling and

Table 2. Frequencies of detectable responses by Northern Goshawks to taped calls in Pennsylvania, 1989, in relation to four experimental factors (N = 55 trials). Frequencies of responses for trials when adults were known or presumed to be near nests (N = 34) are shown in parentheses.

EXPERIMENTAL FACTOR	GOSHAWK RESPONSE DETECTED	
	YES	NO
Period of breeding season		
Nestling	11 (11)	16 (9)
Fledgling	7 (7)	21 (7)
Type of call		
Northern Goshawk	13 (13)	15 (6)
Great Horned Owl	5 (5)	22 (10)
Broadcast distance		
150 m	14 (14)	14 (4)
300 m	4 (4)	23 (12)
Time of day		
Early a.m.	3 (3)	11 (3)
Late a.m.	5 (5)	8 (4)
Early p.m.	4 (4)	10 (6)
Late p.m.	6 (6)	8 (3)
Sequence of broadcast trials		
Trial 1	4 (4)	9 (3)
Trial 2	5 (5)	9 (4)
Trial 3	4 (4)	10 (4)
Trial 4	5 (5)	9 (5)

fledgling periods (Table 2) were not significant for total trials ($G = 1.6$, $P = 0.21$) or for trials with adults present ($G = 0.1$, $P = 0.77$). Similarly, there were no significant differences in response rates between nestling and fledgling periods (total trials) for conspecific ($G = 0.1$, $P = 0.71$) or for owl calls (Fisher's exact test, $P = 0.17$).

There was no difference among times of day for adult goshawks to be observed near nests ($G = 2.4$, 3 df, $P = 0.49$). Response rates among times of day (Table 2) did not differ for total trials (Fisher's exact test, $P = 0.64$) or for trials with adults present (Fisher's exact test, $P = 0.73$). During the nestling period, response rates to total trials were lowest in early morning and higher in late morning and late afternoon (Fig. 3); however, differences among times of day during the nestling period were not significant for total trials (Fisher's exact test, $P = 0.22$) or for trials with adults present (Fisher's exact test, $P = 0.71$).

Response rates did not vary among four sequential

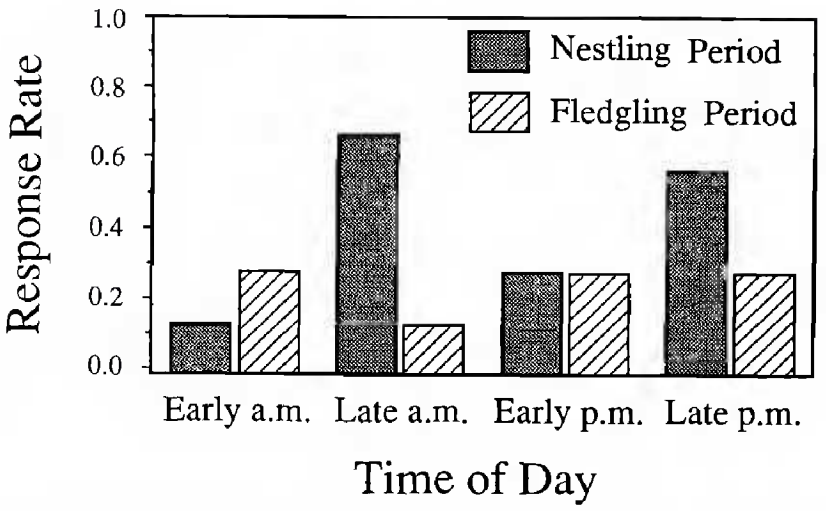

Figure 3. Response rates of Northern Goshawks to taped calls played at four times of day during nestling and fledgling periods (N = 55 trials).

visits to nests (Table 2) for total trials ($G = 0.3$, 3 df, $P = 0.97$) or trials with adults present (Fisher's exact test, $P = 1.0$). Thus, goshawks apparently did not habituate or become conditioned to taped calls played during four trials over a 2-d period.

Response rates of goshawks to conspecific calls versus owl calls (broadcast distances and periods of breeding season combined) (Table 2) differed significantly for total trials ($G = 5.0$, $P = 0.03$) and for trials with adults present ($G = 4.2$, $P = 0.04$). The highest response rate for a given call-distance combination and period of breeding season (Fig. 2) was to goshawk calls at 150 m during the nestling period (0.71). No responses were detected to owl calls at 300 m during either nestling or fledgling periods.

Taped calls elicited higher response rates at 150 versus 300 m (calls and periods of breeding season combined) for total trials ($G = 8.1$, $P = 0.004$) and for trials with adults present ($G = 10.0$, $P = 0.002$) (Table 2). Response rates to owl calls at 150 versus 300 m differed significantly for total trials (Fisher's exact test, $P = 0.04$) and for trials with adults present (Fisher's exact test, $P = 0.03$). Response rates of goshawks to conspecific calls at 150 versus 300 m did not differ for total trials ($G = 3.7$, $P = 0.055$) or for trials with adults present (Fisher's exact test, $P = 0.057$). Although these differences were not statistically significant, we feel they were biologically important and probably reflected an expected decrease in detectability of goshawks to taped calls played at greater distances from the nest.

Time for Response. Goshawks responded quicker to conspecific calls than to owl calls, particularly during the nestling period. Because no goshawk responses were detected to owl calls at 300 m, com-

parisons of time for response were limited to responses at 150 m (Table 3). Median time for response to conspecific calls during the nestling period differed significantly from that to owl calls for any detectable responses ($\chi^2 = 6.0$, $P = 0.02$) and for vocal responses only ($\chi^2 = 5.0$, $P = 0.03$). The difference in median time for vocal responses to conspecific versus owl calls (nestling and fledgling periods combined) approached significance ($\chi^2 = 3.83$, $P = 0.050$). Median time for goshawk responses to conspecific calls played at 300 m was 76 sec (N = 4, range = 30–660 sec).

Table 3. Range, sample size (N), and median time (sec) for detectable responses by Northern Goshawks to conspecific and Great Horned Owl calls played at 150 m from active nests during the nestling and fledgling periods in Pennsylvania, 1989.

Period of Breeding Season / Type of Response	Type of Call	
	Conspecific	Owl
Nestling period		
Vocal response		
Range	10–65	68–455
N	5	3
Median	13	120
Any detectable response		
Range	10–65	68–455
N	5	4
Median	13	95
Fledgling period		
Vocal response		
Range	44–175	70
N	3	1
Median	70	70
Any detectable response		
Range	44–320	70
N	4	1
Median	123	70
Both periods pooled		
Vocal response		
Range	10–175	68–455
N	8	4
Median	52	95
Any detectable response		
Range	10–320	68–455
N	9	5
Median	60	70

Discussion

Marion et al. (1981) indicated that taped calls can be particularly useful for facilitating censuses of elusive and secretive birds. The Northern Goshawk is a shy and inconspicuous woodland raptor, except during the breeding season, when it typically defends its nesting territory from intruders using vocal and aggressive behaviors (Bent 1937). Because censuses of accipiters are best conducted during the breeding season (Reynolds 1982), the use of taped calls should be helpful for increasing detectability of nesting goshawks.

This study demonstrated that the "kakking" call of the goshawk was more effective for detecting nesting goshawks than the "hooting" call of a Great Horned Owl. The conspecific call elicited detectable responses at higher rates, at greater distances, and in less time than the owl call. Moreover, the conspecific call was almost equally effective during nestling and fledgling periods. Thus, we recommend that the goshawk call be used for censuses or surveys of nesting Northern Goshawks.

Our results indicated that a majority of adult goshawks tending nests with young (perhaps 70% or more during the nestling period) may be detected when conspecific calls are broadcasted within 150–200 m of nests. Therefore, if a complete census of breeding pairs in a prescribed area is desired, we recommend that transects be spaced no more than 300 m apart and that taped calls be played at broadcast stations spaced every 150–200 m along transects. Further, we recommend that at least two full bouts of "kaks" be played alternately to each side of the transect at each station and that the minimum duration of a broadcast at a station be 1 min (including periods of silence between bouts of "kaks").

Despite apparent variation in response rates of goshawks to taped calls among four times of day during the nestling period, we found no significant difference. Balding and Dibble (1984) believed that Red-tailed, Red-shouldered, and Broad-winged Hawks responded more often to taped calls in mid-morning, and Fuller and Mosher (1987) suggested that surveys of woodland hawks using taped calls should be conducted in morning. It is possible that accipiters and buteos might respond differently to taped calls relative to time of day, because buteos rely heavily on mid-day thermals for soaring flights that function in part for territorial defense (Newton 1979).

We tested taped calls only during nestling and

fledgling periods. This experiment could be repeated to evaluate response of goshawks to taped calls at other times of the breeding season, such as before and during incubation. Potential advantages of using taped calls for censuses earlier in the breeding season include greater visibility and better sound transmission through the forest prior to leaf-out (Morton 1975). However, raptors generally respond less to taped calls during incubation than at other times during the breeding season (Fuller and Mosher 1981). Red-shouldered and Cooper's Hawks respond to taped calls prior to incubation (Fuller and Mosher 1981, Rosenfield et al. 1985), and we expect goshawks also would respond to taped calls at this time. Goshawks might even respond to taped calls at greater distances prior to incubation, because nests would not yet contain eggs or young. However, responses to taped calls at this time may be less vocal (and thus less detectable) than responses later in the breeding season (M. Root and P. DeSimone, unpubl. data).

Although this study was not intended to evaluate the effect of recent nest failure on response of goshawks to taped calls, we played goshawk and owl calls six and four times, respectively, at four failed nests. Two nests failed due to presumed predation of goshawk young by Great Horned Owls, one due to probable predation of eggs by a raccoon (*Procyon lotor*), and one due to nest destruction by high winds. These trials were conducted an estimated 1–2 wk following nest failure, and none resulted in detectable response by goshawks. If goshawks cease defending nests subsequent to nest failure, censuses using taped calls late in the breeding season might underestimate the number of breeding pairs that were present at the start of the breeding season.

Raptor censuses generally are expensive and labor intensive (Fuller and Mosher 1981). Reynolds (1982) recommended searching a minimum area of 9000 to 12,000 ha to determine densities of nesting accipiter hawks. Techniques that maximize the effective search area of individuals conducting raptor censuses are needed to make raptor population studies more feasible. The use of taped calls, perhaps coupled with stratification of large study areas using a predictive habitat model, may provide wildlife biologists with an approach to conduct more efficient and effective censuses of nesting Northern Goshawks.

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